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(54) METHOD AND APPARATUS FOR CLEANING FABRIC FILTERS OF BAG TYPE OR THE LIKE

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ABSTRACT OF THE DISCLOSURE

A method of and apparatus for cleaning fabric filters of bag type or the like by exposing the filter bags to a pressure pulse of cleaning medium which is supplied to the filter bags through a cleaning apparatus comprising a pressure tank for containing the filter medium in the form of a gaseous medium under pressure, preferably compressed air. A distribution passageway communicating with the tank and provided with nozzles or orifices is directed to the apertures of the bags, a valve means and control means are provided for producing the pressure pulse. An end of the distribution passageway which projects into the pressure tank is covered by a valve means in the form of a disc or diaphragm and surrounded by pressure medium and is exposed rapidly whereby the pressure pulse in the bag reaches a high maximum value with high velocity in pressure increase.

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METHOD AND APPARATUS FOR CLEANING FABRIC FILTERS OF BAG TYPE OR THE LIKE

This invention relates to a method of cleaning fabric filters of bag type or the like by exposing the filter bags to a pressure pulse of cleaning medium, which is supplied to the filter bags through a cleaning apparatus comprising a pressure tank for containing the cleaning medium in the form of gaseous medium under pressure, preferably compressed air, a distribution passagaway communicating with said tank and provided with nozzles or orifices directed to the apertures of the bags, a valve means and control means for producing the pressure pulse.

A plurality of different cleaning principles are applied in conjunction with fabric filters, for example cleaning by vibration, shaking, return air injection, compressed air pulses, sound pulses, and combinations of said principles. The principle substantially being dealt with in the following is cleaning by compressed air pulses, hereinafter also called pressure pulses.

In principle, cleaning by compressed air pulses is carried out in such a manner, that the compressed air is distributed from a tank via a system of passageways to the fabric filter configuration in question, which e.g. may consist of bags, and is injected into the bags through some kind of nozzle. The cleaning air flow

having opposed direction relative to the operation gas flow cleans the bag of collected dust particles. The jet energy of the pressure pulse in the nozzle outlet is utilized for the co-ejection of surrounding air in order to rapidly fill the bag volume and obtain a large reversible through-flow (so-called ejected pulse). In most cases ejectors are utilized at the bag inlet for producing a good co-ejection effect. The pressure in the pressure tank usually is chosen to lie in the high-pressure range, i.e. that the excess pressure is between 0,4 MPa and 0,8 MPa. There exist also systems operating with lower pressure, for example between 0,1 MPa and 0,2 MPa, and with a smaller or none ejecting flow (so-called direct-pulse). The object in such cases is to utilize the greater part of the jet flow directly for bag cleaning. One disadvantage of the conventional systems, however, is that the compressed air consumption is higher than at systems operating according to the ejected-pulse principle. Moreover, the cleaning effect obtained at the known systems often has been unsatisfactory and thereby has jeopardized the serviceableness of the filter installation.

By a detail study of the dynamic procedures in a conventional direct-pulse system, the way in which the cleaning effects are obtained, has been elucidated in detail. It was a.o. found, by registration and evaluation of the pressure developments in the tank, piping and bags and by direct comparisons with results obtained from pilot-scale and full-scale tests in real installations, that the most essential cleaning effect was obtained by the pressure chock in the bag which preceded the air through-flow proper, i.e. the acceleration-retardation procedure, which is forced onto the filter

medium with the dust particles collected thereon, is more essential from the cleaning aspect than the subsequent through-flow. It was, thus, discovered that, for rendering the filter cleaning more efficient, it is essential to produce an improved acceleration effect on the bag, and that this increased acceleration is to be brought about during the build-up of the pressure pulse in the bag.

The invention is based on the understanding of that the time for the pressure pulse to reach its maximum value is as much as possible to be shortened, while the maximum value of the pressure pulse is to be set as high as possible. For realizing this object, a certain geometric relation between nozzle and filter medium configuration, for example bag, is required. The pressure transfer from nozzle to bag which can be described by the impulse law and has been attested by practical tests, is most effective when the bag inlet and nozzle location are so chosen that as little as possible surrounding air is co-ejected. The velocity in pressure increase and the size of the maximum pressure pulse in the bag, further, are influenced by the flow losses of the air system, i.e. the energy available must be concentrated to the greatest possible extent to the air jet proper ejected from the nozzle. Of course, this is technically selfevident, and it is conventionally carried out also with a view on the manufacturing cost aspects. In a conventional system, the flow losses can be said being concentrated

to the valve, distribution pipe (friction and air distribution losses) and nozzles (inlet nozzles). The losses in the distribution pipe and nozzles can be affected in a conventional manner by changing the dimensions. This is, of course, also the case for the valve, but in order to, besides, bring about the higher velocity in pressure increase in the bag and possibly be able to interrupt the procedure immediately after the maximum and increased pressure pulse in the bag has been obtained, a more rapid and fully controlled opening and closing function than obtained with a conventional system build-up is required.

The present invention, therefore, relates to a method of cleaning fabric filters according to the direct-pulse principle and has as its object to provide a method, by which the efficiency of the cleaning is substantially improved and the air consumption is reduced.

One broad aspect of the invention relates to apparatus for cleaning bag-type fabric filters comprising a pressure tank for containing pressurized gaseous medium, a gas distribution conduit provided with at least one flow opening for applying pressurized gas to the surface of a filter opposite the surface having dust particles collected thereon, said distribution conduit having an end opening into the pressure tank and forming a valve seat within the tank, a movable valve member disposed within the tank for opening and closing the valve seat, and fluid pressure control means for exerting a fluid pressure on the movable valve member to move the same into engagement with the valve seat.

The invention and its relation to known art is described in greater detail in the following, with reference to the accompanying drawings, in which

Fig. 1 shows in a schematic way the construction of a conventional blow cleaning system,

Fig. 2 is a diagram showing the pressure development in the tank and bag as a function of the time at a conventional system,

Fig. 3 shows a nozzle and bag at a direct-pulse system,

Fig. 4 shows in a schematic way constructions of the blow cleaning system according to the invention,

Fig. 5 shows in detail the valve with the diaphragm in open position,

Fig. 6 shows the valve diaphragm,

Fig. 7 is a diagram showing the pressure relation in the tank and bag as a function of the time at a system according to the invention,

Fig. 7a is a diagram showing the control impulse to the valve,

Fig. 8 is a diagram showing the control impulse to the valve at a so-called pulse train,

Fig. 9 shows in a schematic way a pressure tank divided into sections .

In Fig. 1, which refers to a conventional blow cleaning system according to the direct-pulse principle, the numeral 1 designates a pressure tank for cleaning medium in the form of compressed air. To said pressure tank is connected a pipe 2, which is coupled to a valve 3. Upon opening the valve, a pressure pulse is produced which is led via the distribution passageway 4 to nozzle pipes 5, which are directed to the openings of the bags 6. The diagram in Fig. 2 shows more clearly the pressure conditions in the tank and bag when the valve is being opened. The curve A represents the pressure

drop in the tank after the valve has been opened, and the curve B represents the pressure development in the bag. The time T1 represents the time for the bag pressure to rise from operation pressure to maximum pressure, which is designated by P_b. After the pressure has reached its maximum, a continuous decrease in pressure takes place owing to the air flowing out through the filter medium. It was proved by a plurality of pilot - as well as full-scale tests, that the cleaning effect was not influenced when the time for which the valve had been held open was shortened from 0,7 second to about 0,2 second. These time intervals are indicated in Fig. 2 by T3 and T2, respectively. It was found that it were the velocity in pressure increase represented by the time T1, and the maximum value P_b of the bag pressure chocks which render the essential cleaning effect. The subsequent flow of air through the filter medium is of minor importance in this respect. This was also confirmed by means of theoretical calculations.

In Fig. 3 is shown the location of the nozzle 5 in relation to the bag 6. It was found that, in order to obtain a minimum co-ejection of surrounding air, the distance <u>h</u> between the outlet of a nozzle and the bag inlet must be chosen being between 25mm and 175mm for relations between nozzle and bag diameter d_1/d_2 of 0,012-0,030. Fig. 4 shows the construction of a blow cleaning system according to the invention. The pressure tank 1 contains the cleaning medium in the form of compressed air. The distribution passageway 4, which communicates with the pressure tank, is provided with nozzle pipes 5 or alternatively apertures 7 directed to the

bag opening. Said distribution passageway also comprises a portion 9, which projects into the tank and the end of which, thus, opens into the tank. The two passageway portions 4 and 9 can be manufactured integral or be connected to each other by a coupling means 10, which may be designed, for example, with bayonet socket or as a flexible coupling with rubber sleeve and hose clips. At the end of the distribution passageway a valve means 8 is provided, which comprises a valve diaphragm 11, which in the position shown sealingly abuts a valve seat 12 disposed at the end of the distribution passageway. An O-ring may serve as a sealing between the distribution passageway and the valve seat. For fixing the end of the distribution passageway (and valve seat) with the shell surface of the tank, a connection 13 is provided. The valve diaphragm is actuated by a pilot valve 14, which in its turn is controlled by a control system (not shown). The main requirement to be met by the control system is to emit control signals of sufficient speed. This can be realized in different ways by known art. It is presupposed in the following that the signals are emitted in the form of electric pulses. The valve means may also, within the scope of the invention idea, be given a location other than that at the embodiment shown. The extended portion 9 of the distribution passageway, for example, can be made very short so that the valve seat in practice will be located close to the tank shell surface where the passageway penetrates the tank wall. In such a case, the main part of the valve means will be located within the tank.

In Fig. 5 the valve means is shown in detail when the diaphragm 11 is in open position. An annular gap t is then formed between the valve seat 12 and diaphragm 11. In order to render the function satisfactory, the annular area $A_O = \pi \cdot d_O \cdot t$ for the air inlet is about the same as the cross-sectional area in the distribution passageway which is equal to $\pi d_O^2/4$. As a result of assembling the valve with the pressure tank, as shown in Figs. 4 and 5, very low flow losses are obtained. This, together with a rapid opening function of the valve, provides the prerequisites for both the high velocity in pressure increase and an increased, maximum pressure pulse in the bag. As an example can be mentioned that at measurements made for a 3-inch valve a pressure drop coefficient (defined according to the relation $\Delta p = \zeta \cdot p_{dyn}$) for the integrated valve function was obtained which was 20 per cent lower than the valve for the conventional valve function according to Fig. 1. Due to the fact that the valve is completed with a rapid control system, also a very rapid closing of the valve is obtained. This, adding up, renders it possible to obtain a time interval between opening and closing of the valve which is very short, compared with conventional systems. Hereby the procedure can be interrupted immediately after the maximum pressure pulse has been obtained in the bag and thereby renders possible a substantial reduction of the air consumption.

Fig. 6 shows in detail the valve diaphragm 11 provided with a so-called blow-off cock.15. The diaphragm can be modified so as to match the opening and closing times with each other

to an optimum combination. At measurements made on a commercially available valve make, for example, a diaphragm opening time of 0,005 second and closing times of 0,03-0,05 second at a tank excess pressure of 0,11 MPa were obtained. By providing the diaphragm with three to four blow-off holes of 3 mm diameter, certainly a twice as long opening time was obtained, but the closing time was reduced to about its half, which resulted in a shortened total of opening and closing times. The figures mentioned, thus, refer to a certain diaphragm mass, diaphragm rigidity and tank pressure. For higher pressures, for example, a thicker (=stronger) diaphragm is required which, consequently, has a greater mass and requires other combinations of blow-off holes or corresponding measures.

In the following, the development of a pressure pulse is described in greater detail, reference being made to the Figures 7 and 7a. Fig. 7 is a diagram showing pressure $\underline{p}$ as a function of the time T, and Fig. 7a, superimposed in Fig. 7, shows the control impulse S as a function of the time. In Fig. 7, the curve C represents the pressure relation in the pressure tank, the curve D represents the pressure relation in the filter-media configuration, which e.g. may be a bag, and curve E in Fig. 7a indicates the electric impulses controlling the opening and closing of the valve. The impulse level S_0 corresponds to impulse for closed valve, and the impulse level S_1 refers to impulse for open valve. After the electric impulse for valve opening has been released, a certain time TO, the

so-called dead time, lapses before the physical valve opening commences. The opening time for the valve is T4 whereafter the dynamic flow is fully developed and causes the pressure rise in the bag to the maximum value P_b. When after the release of the electric control impulse a certain time has lapsed, the closing procedure commences thereby that the electric control impulse is broken. The length of the electric pulse is designated by T_e. When again a dead time TO has lapsed, the physical valve closing is commenced which takes the time T5. The time during which the valve is open, thus, is corresponded by the time T7. The time T6 is required for emptying the system. As pointed out earlier, it is the procedure portion being essential from the cleaning point of view, which is to be utilized, viz. the rapid pressure pulse increase in the bag, i.e. the pressure rise which takes place during the time T8. Therefore, the procedure is to be interrupted as soon as the pressure pulse in the bag has reached its maximum value. This may imply, due to the shifting in time between the procedures in the valve and in the bag, that the electric impulse for valve closing must be given even before the pressure pulse in the bag has reached its maximum value. The electric pulse time T_e between opening and closing, therefore, is made very short, 0,02 to 0,10 second , compared with conventional systems where the time is about 0,15 to 1,0 second. As an example can be mentioned that at tests with a system described above the electric impulse time for opening/closing was chosen at one occasion 0,040 second, at which occasion the time during which

the valve was open, inclusive of the opening and closing time, was about 0,075 second. Times as short as about 0,020 second (electric impulse time) could be applied before a decrease in size of the compressed air pulse of the bag occurred. A corresponding pressure drop Δp in the tank (tank volume 0,5 m^3) was 5000-40 000 Pa at an excess pressure in the tank which in the starting position was about 110 000 Pa corresponding to a compressed air consumption of 0,020-0,20 m^3 free air per blowing. Corresponding measurements in a conventional system according to Fig. 1 rendered air consumption figures of 0,40-0,60 m^3 free air per blowing and a maximum pressure pulse in the bag which was lower by as much as 60%.

The velocity in pressure increase, defined as Δp bag/Δt, which is achieved in the bag, has also been measured. As an example of the average velocity in pressure increase, i.e. $P_b/T8$, can be mentioned that by application of the invention a value exceeding 400 000 Pa/s (Pascal per second) has been obtained at 0,11 MPa (megapascal) excess tank pressure and more than 1 200 000 Pa/s at 0,25 MPa excess tank pressure. It can, further, be mentioned that this velocity in pressure increase is four to six times higher than that obtained with known art.

Compared with known systems the invention, thus, offers both a substantial improvement of the cleaning effect and a reduction of energy consumption.

It should, further, be pointed out that the maximum pressure pulse P_b in the bag, of course, also is affected by the pressure prevailing in the tank. The object with the invention is to utilize primarily the low-pressure range with a tank excess pressure of 0,05-0,3 MPa, but it may be necessary

for certain applications also to utilize the high-pressure range (0,3-1,0 MPa). Such utilization, thus, lies within the scope of the invention idea. The decision which tank pressure is to be chosen, is in practice a problem of optimizing, for which the entire filter function and the process application in question must be taken into consideration.

The diagram in Fig. 8 shows a variant of the control principle at which two or more pulses tightly following each other, so-called pulse trains, are produced. The time T_e designates the length of a control pulse, and the time T_s refers to the time interval between the beginning of two subsequent pulses. The pulse train can be obtained in a simple manner by electric forced control, so that a subsequent pulse already begins before the pressure in the tank has reassumed its original value, or first after said value has been reassumed. In order to achieve the greatest effect in relation to the air consumption, short time intervals are to be chosen. Suitable values are 20-50 ms electric impulse time T_e and a time difference T_s about twice as great between the pulse train chocks. For a specific case, the values T_e = 35 ms and T_s = 70 ms have been tested. The effect of such a pulse train system, of course, depends to some extent on the capacity of the pressure producing system available, but irrespective thereof has been noted at tests in installations, that an additional improvement of the cleaning effect, compared with only one pulse, is obtained. In order to limit the compressed air consumption, it is possible to limit the volume of the tank, instead of substantially short-

ening the time during which the valve is held open. For special applications and sizes, the air consumption figures thereby obtainable are almost as low as if the valve is given a short holding-open time. The smallest tank volume, which can be used without reducing the amount of the maximum pressure pulse in the bag, is five to ten times greater than the volume of the air distribtion passageways. Fig. 9 shows how the limited tank volume can be brought about at the construction of a full-scale installation. The pressure tank 1 is provided with distribution passageways 4 (shown partially). The tank is divided by a partition wall 16 into sections, so that the volume of each tank section is so adjusted to the volume of the associated distribution passageways that the aforesaid requirements are met.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Apparatus for cleaning bag-type fabric filters comprising a pressure tank for containing pressurized gaseous medium, a gas distribution conduit provided with at least one flow opening for applying pressurized gas to the surface of a filter opposite the surface having dust particles collected thereon, said distribution conduit having an end opening into the pressure tank and forming a valve seat within the tank, a movable valve member disposed within the tank for opening and closing the valve seat, and fluid pressure control means for exerting a fluid pressure on the movable valve member to move the same into engagement with the valve seat.

2. Apparatus as in claim 1 wherein the distribution conduit extends into the tank at one location on the tank wall so that the valve seat is disposed near an opposite location on the tank wall.

3. Apparatus as in claim 1 wherein the valve seat and the movable valve member in the open position form an annular gap the cross-sectional area of which is substantially equal to the cross-sectional area of the distribution conduit.

4. Apparatus as in claim 1 wherein the volume of the pressure tank is 5-20 times the volume of the distribution conduit.

5. Apparatus as in claim 1 including a filter housing having a plurality of bag type filters therein and wherein said cleaning apparatus is connected to the filter housing such that the flow apertures in the distribution conduit are disposed adjacent the filter surfaces opposite the dust-collecting surfaces.

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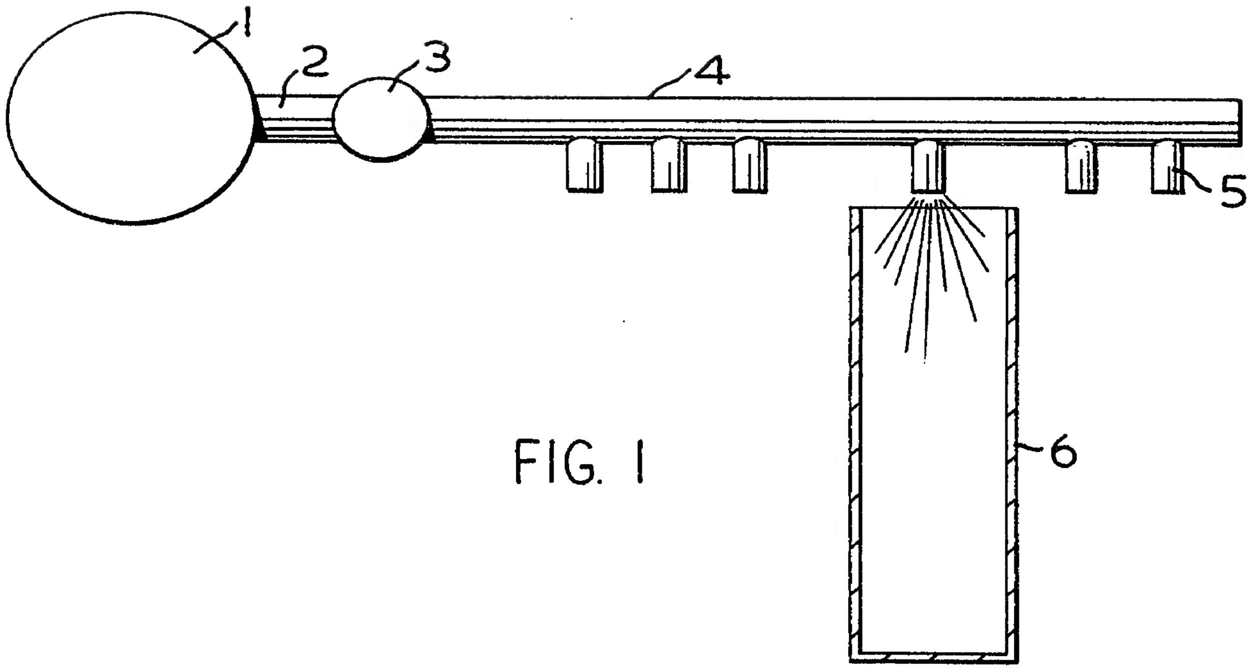

FIG. 1

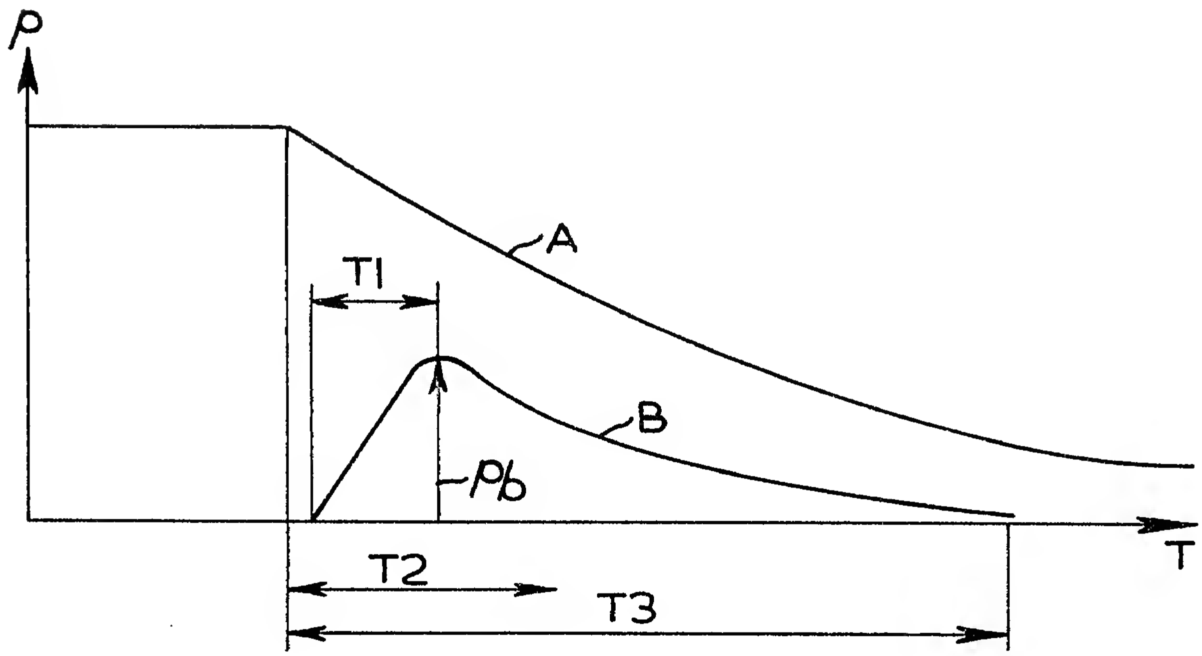

FIG. 2

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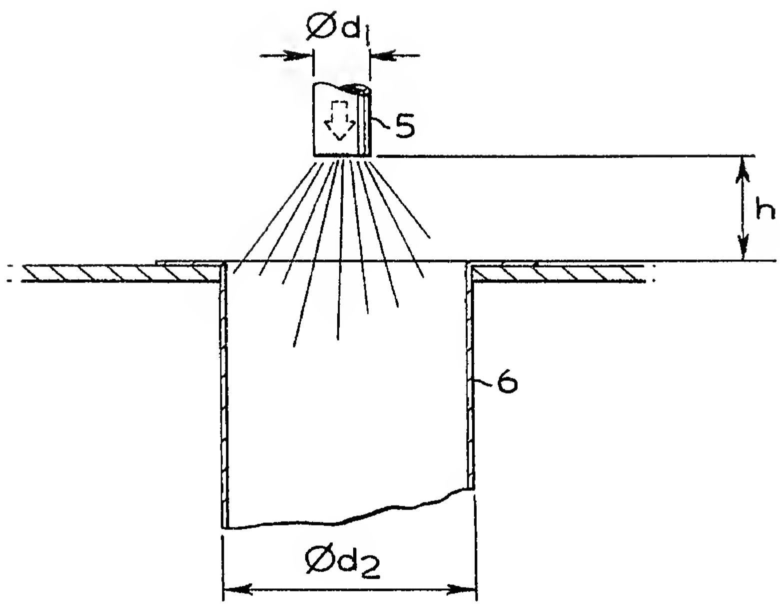

FIG. 3

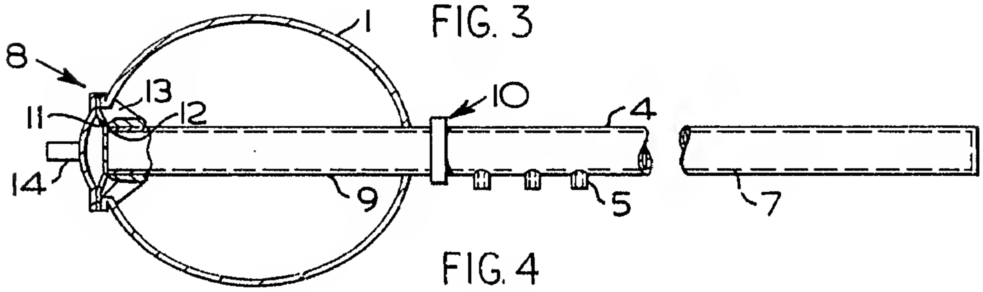

FIG. 4

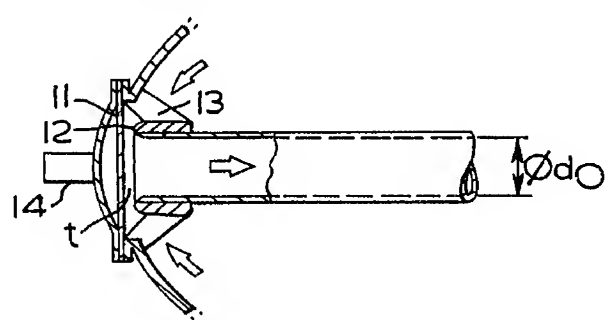

FIG. 5

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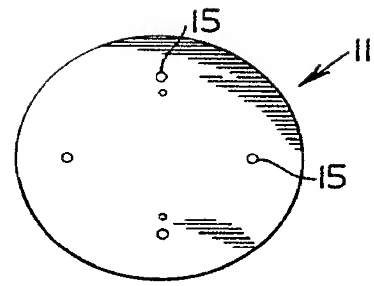

FIG. 6

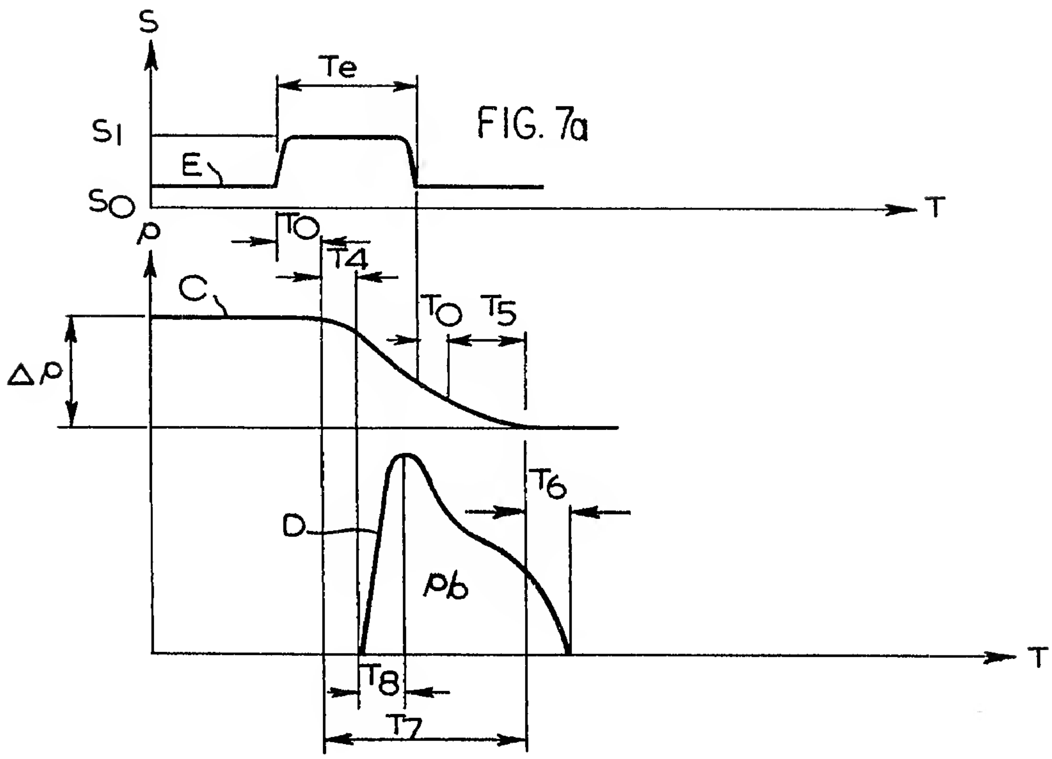

FIG. 7

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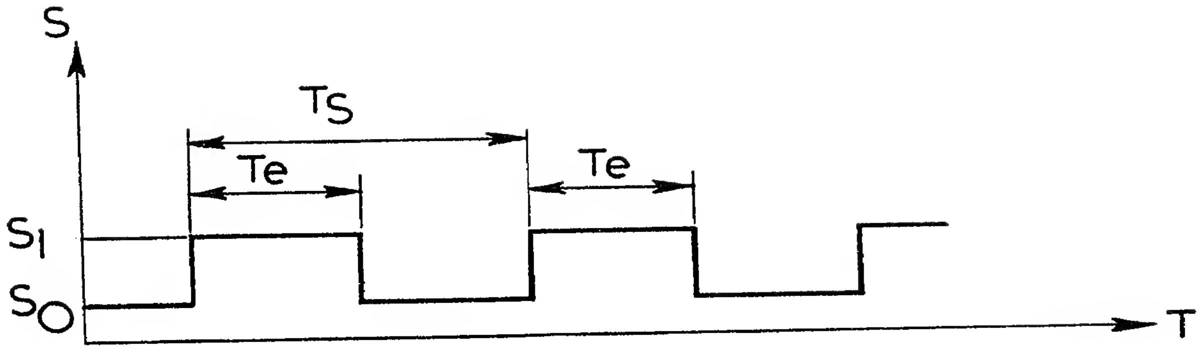

FIG. 8

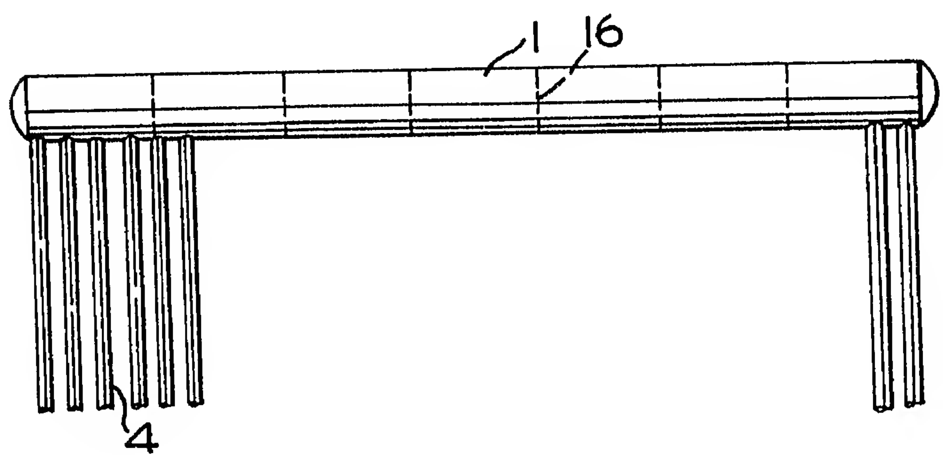

FIG. 9

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